Let nothing slip away

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Innovative solutions are needed to reach the ambitious climate neutrality and emission reduction goals established by the International Maritime Organization (IMO) and the European Commission (COM) at the international and European levels. Massive energy consumption reductions are foreseen, but cleaner low-carbon energies will also play an essential role in this transition. Regarding maritime transport, liquefied natural gas (LNG) solutions can enable this green future if the methane slip challenge is addressed. The GREEN RAY project proposes three innovative technologies for LNG engines that can be installed on new and existing ships and will drastically reduce the methane slip, contributing to climate action and a healthier society.

The transport sector accounts for **a quarter** of the European Union's total greenhouse gas emissions (GHG-E). In particular, shipping was responsible for **153.9mt of CO_2 emitted in the EU 27 in 2019,** contributing to climate change and compromising air and water quality through fuel-based pollution, affecting not only the environment but also human health.

As part of the **Fit for 55** legislative package, a plan to reduce net GHG-E by at least 55% by 2030, COM released a proposal for a **FuelEU Maritime** regulation in July 2021. It aims to reduce the carbon intensity of the energy used by maritime transport by stimulating the uptake of sustainable marine fuels and zero-emission technologies to reach a 90% reduction in transport emissions by 2050 vs 1990 levels.

This goal of the EU follows the lead established in 2018 by IMO. The IMO released their **Initial GHG Strategy**, aimed at reducing CO_2 emissions by a minimum of 40% by 2030, up by 70% by 2050, and halving total emissions by 2050 vs 2008 levels. This Strategy will be revised and updated next year.

These goals are ambitious and will not be reached by only reducing the sector's energy consumption through fuel efficiency. Alternative low-carbon energy sources are therefore also needed. Following the successful adoption of several IMO regulations on emissions of nitrogen oxides (NO_X) and sulphur oxides (SO_X), LNG has emerged as a strong contender to replace heavy fuel oil.

According to **SEA-LNG's January 2022 report**, the past year was a record one in both the growth of LNG as a marine fuel and the number of orders for gas-fuelled vessels. They estimate that 30% of the gross tonnage ordered corresponds to LNG-run newbuilding orders, and "for some segments, such as the ultra-large container vessels which underpin the global trading system, more than 50% of the order book is either LNG-fuelled or LNG-ready."

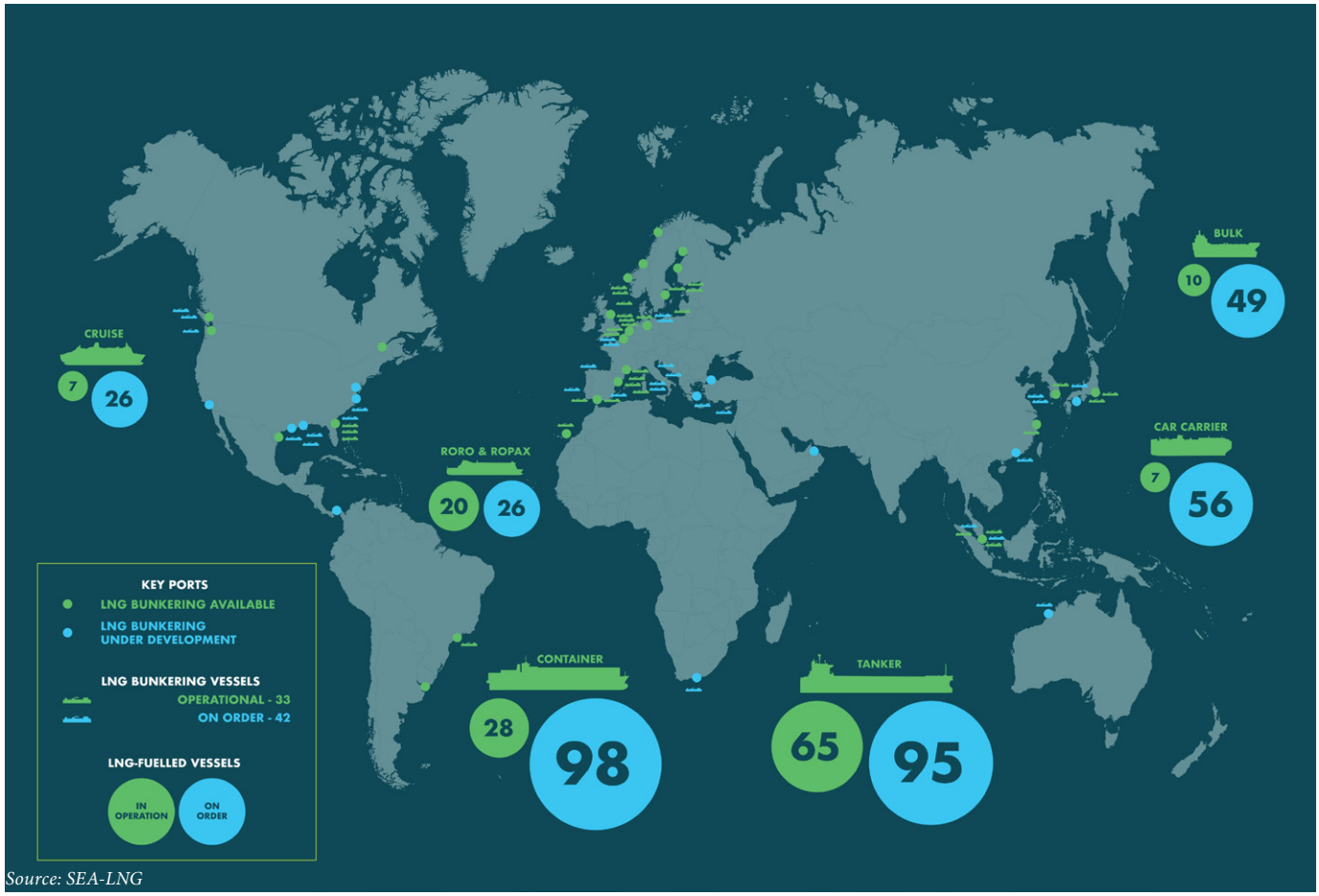
Further reduction

The emissions profile of LNG is favourable relative to oil-based fuels, both in terms of particle emissions and NO_X and SO_X, as well as lower overall well-to-wake GHG-E. The shift to LNG has improved overall air quality and reduced water and soil acidification. However, methane slip – the escape of methane not burned as fuel into the atmosphere – remains a considerable challenge that needs to be minimised in the context of increasing LNG use: **methane has a global warming potential 28-34 times that of CO_2 on a 100-year timescale**.

There are several ways to reduce methane slip from LNG-powered ships to negligible amounts or even eliminate it. Wärtsilä has cut it from its dual-fuel engines **by 85% since 1993**. As a result of the new technologies they are developing, they also expect to reduce methane slip further: by more than 50% to roughly 1.0 gram per kWh while keeping the NO_X, SO_X, and particulates at the same level.

One of these innovative processes is being developed under the GREEN RAY, a Horizon Europe project. Coordinated by VTT Technical Research Centre of Finland, it brings together partners from across the shipping value chain: Chantiers de l'Atlantique, CMA SHIPS, Wärtsilä, Shell, DNV, the Finnish Meteorological Institute, the Cruise Division of the MSC Group, as well as the sustainability-focused communications agency REVOLVE.

Fig. 1. Worldwide growth in LNG use and infrastructure



Source: SEA-LNG

Targeted from multiple angles

The goals of the project comprise assessing methane emissions from existing and new LNG vessels; developing technologies to reduce methane slip in two- and four-stroke LNG engines; developing an after-treatment technology to further minimise methane slip; producing scenarios for shipping emissions and how GREEN RAY technologies can contribute to GHG-E reduction; and enabling the utilisation of the project results to maximise long-term research impacts.

GREEN RAY will target the low-pressure dual-fuel concept, currently the most popular LNG engine technology, to prevent methane slip. The project partners will provide solutions to reduce methane slip in two- and four-stroke engines as well as tackle remaining methane slip through the development of an after-treatment technology to convert it into a less potent greenhouse gas.

For four-stroke engines, the solution will aim to enable methane slip reduction at all engine loads, applicable to the largest engines in the market (including cruise ships, ferries, gas carriers). GREEN RAY aims to significantly decrease methane emissions based on the developments of numerous systems (gas fuel, liquid fuel injection, engine charge air delivery) and engine control. This technology could provide a 40% overall reduction of methane slip.

Regarding two-stroke engines, GREEN RAY will develop a new LNG injection system that will significantly reduce methane slip by improving spray distribution and combustion behaviour compared to gas injection. This engine solution aims to substantially reduce methane slip from, e.g., tankers and container ships. This development could lower methane slip by 70%.

Thirdly, as a backstop for remaining methane emissions, GREEN RAY is developing a catalytic abatement system comprising a high-capacity sulphur guard bed and a low-temperature methane oxidation catalyst. This system will significantly reduce methane slip emissions, up to 95%, to less than 1.0g/kWh.

A more comprehensive outlook

The developed technologies will be demonstrated aboard three ships: two new and one retrofitted. Partners will also contribute to the collection of climate data through the study of methane levels. These will allow for a more global assessment of GHG-E from LNG as a marine fuel and will be combined with onboard experiments and modelling to provide a more comprehensive outlook of the climate impacts of maritime transportation.

Ultimately, GREEN RAY can help make LNG a cleaner energy source as it spreads as an alternative fuel for European and international maritime transport. ■

GREEN RAY

The GREEN RAY project aims at minimising methane slip from liquefied natural gas (LNG) vessels to enable clean waterborne transport. By developing three innovative technologies for LNG engines that can be installed on new and existing ships, GREEN RAY is working to reduce the negative impact of waterborne transport and protect human and environmental health. The GREEN RAY project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056642. Go to **greenray-project.eu** to learn more.